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MANUFACTURING METHOD OF CORELESS ARMATURE COIL AND BRUSHLESS CORELESS MOTOR USING SAID COIL
[Koaresu amachua koiru no seizo hoho oyobi gai koiru wo mochiita burashiresu koaresu mota]

Teruomi Nakaya et al.

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INVENTOR	(72):	NAKAYA, TERUOMI; OKAMOTO, OSAMU; SUZUKI, SEIZO; KUWANO, NAOAKI; TAKESHITA, YASUHIRO; TANIGUCHI, YASUAKI; IBA, TAKAJI; HARA, HIROMITSU; HAMADA, MAKOTO
APPLICANT	(71):	DIRECTOR, NATIONAL AEROSPACE LABORATORY, SCIENCE AND TECHNOLOGY AGENCY; KAWASAKI HEAVY INDUSTRIES, LTD.; FUJIKOSHI K.K.
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Specification /1*

1. Title of the Invention

Manufacturing method of coreless armature coil and brushless coreless motor using said coil

2. Claims

1) A manufacturing method of a coreless armature coil, comprised of forming a flat coreless frame-like coil having a gap in the center, shaping the coreless frame-like coil into a bracket shape by curving the same and bending the upper side and lower side in the same direction, and sequentially affixing the coil to a coil fixing ring made of a magnetic body such that the parallel-running vertical side of the coil faces the inner perimeter or outer perimeter of the coil fixing ring to form a coreless armature coil.

2) A manufacturing method of a coreless armature coil as defined in Claim 1, wherein said coreless frame-like coil is shaped into two or more kinds of coils of bracket shapes with slightly different heights, the two or more kinds of coils are placed shifting the phase with respect to each other such that one vertical side of one coil is positioned respectively in the gap of another coil, and they are sequentially affixed to the coil fixing ring.

3) A brushless coreless motor, comprising a coreless armature coil with polyphase pairs of flat coreless four-sided frame-like coils affixed in multipole placement to a ring-shaped frame, and a ring-shaped

*Numbers in the margin indicate pagination in the foreign text.

fixing element with a multipole permanent magnet placed opposite the vertical side of the coreless armature coil, and having a penetration space in the center.

4) A brushless coreless motor as defined in Claim 2, wherein said coreless armature coil is shaped into a bracket shape by bending into substantially right angles the opposing upper side and lower side of the coreless four-sided frame-like coil having a gap in the center, and is sequentially affixed to a coil fixing ring made of a magnetic body with the parallel-running vertical side facing the inner perimeter or outer perimeter of the coil fixing ring.

5) A brushless coreless motor as defined in Claim 3, wherein said coreless armature coil comprises a plurality of kinds of coils shaped into bracket shapes with slightly different heights, and the plurality of kinds of coils is sequentially affixed to the coil fixing ring shifting the phase such that one vertical side of one coil is positioned in the gap of another coil. /2

6) A brushless coreless motor as defined in Claim 3, 4, or 5, wherein said coreless four-sided frame-like coil is a sheet coil being a wirewound coil.

7) A brushless coreless motor as defined in Claim 3, 4, or 5, wherein said coreless four-sided frame-like coil is a sheet coil.

8) A brushless coreless motor as defined in any of Claims 3 through 6, wherein said rotating element [sic; not mentioned above] is supported so as to rotate freely by way of a bearing on the inner perimeter or outer perimeter of the ring-shaped frame of said fixing element, an encoder for rotation position control of the rotating element is

provided between said ring-shaped frame and said rotating element, and a controlled member (driven member) can be established to penetrate the penetration space in the middle.

9) A brushless motor as defined in any of Claims 3 through 8, wherein said brushless coreless motor is a DC brushless coreless motor.

3. Detailed Explanation of the Invention

(Industrial Field of Application)

The present invention relates to a brushless coreless motor constituted by a coreless armature coil and a multipole permanent magnet and having a penetration gap in the center, and a manufacturing method of the coreless armature coil thereof.

(Prior Art)

From the past, as brushless coreless motors, there have been known those of axial air gap type, and there are many kinds in the constitution thereof, but they can be largely classified from the viewpoint of the shape of the electric motor coil into flat shutter-shaped coils and flat spiral sheet coils. In the structures of two-phase multipole axial flux-type brushless coreless motors of the past, a flat shutter-shaped wirewound electric motor coil is provided in the perimeter of a shaft coupling part on a base plate, a comma-shaped rotor affixed with a permanent magnet is supported on a shaft, holding between a donut-shaped FG coil, Hall element, and rotational output is extracted by the shaft. Also, the electric motor coil is constituted by overlaying two phases or three phases of coils (A-phase coil, B-phase coil, C-phase coil) shifting the phase with respect to each other and sequentially

placing these on the perimeter. In the past, there have been known those having added improvements to the shapes of the coils such as by making the curved part on the wider side of the shutter-shaped coil thicker than the other part in order to increase the efficiency of this kind of flat shutter-shaped wirewound coil (for example, publication of Japanese Laid-Open Patent No. 61-195739).

Also, the structures of sheet coil-type brushless coreless motors are basically the same as axial flux-type motors, but etching schemes are used in place of wound wire.

Of radial air gap-type brushless motors, there are generally known those with the armature coil having a core. In radial air gap-type brushless DC motors, in the case with a slot, the armature coil is held in the slot part of a laminate core, and in the slotless case, a stator is constituted by holding a ring-shaped core inside a bobbin made of resin and fixing by adhering the coil to the outer perimeter of the bobbin, and a rotor is constituted by placing a permanent magnet on a cup-shaped rotor yoke so as to surround the stator.

(Problems that the Invention is to Solve)

Because the flat-shaped coils of the flat-type brushless coreless motors of the past have electric motor coils formed by overlaying two phases or three phases as pairs on the axis of rotation, between the lower A-phase coil and the upper B-phase coil, there respectively arises a difference in distance from the permanent magnet (rotor) on the side of the rotating element, and in order to make the operating force of the A-phase and B-phase coils equal, respectively different power control, and the like, was required. Also, because the operating force according

to the difference in distance is inversely proportional to about the square of the distance, there arise limitations in thickness. Furthermore, because the shapes of the coil and the permanent magnet are shutter-shaped and the [distance] between the poles (N-S) becomes as short as the inside, there is a flaw that the operating force becomes smaller.

Also, with radial air gap systems, the winding of the wire of the armature coil is complex, the method of that winding of the wire is difficult to automate, and dependence on manual work is the present state, so there are problems such as the manufacturing efficiency being poor.

Furthermore, because the brushless motors of the past generally are provided with a rotating shaft in the position of the center of the axis of rotation, there are problems that it is not possible to provide a large penetration space in the center of the axis of rotation, its out- /3
put schemes are limited, and their uses are limited.

The present invention was conceived in order to solve the abovementioned problems of the brushless motors of the past, and it aims to provide a brushless coreless motor and a manufacturing method of the armature coil of that motor in which a coil can be obtained with equal operating force of each phase of coil, there is little torque ripple, the control is simple, furthermore the assembly of the armature coil is simple, moreover it is possible to form a large penetration space in the center, and diversification of output modes can be designed.

(Means of Solving the Problems)

In order to solve the abovementioned problems, the present

invention manufactures a coreless armature coil by forming a coreless frame-like coil having a gap in the center, shaping the coreless frame-like coil into a bracket shape by curving the same and bending the upper side and lower side in the same direction, and sequentially affixing the coil to a coil fixing ring made of a magnetic body such that the parallel-running vertical side of the coil faces the inner perimeter or outer perimeter of the coil fixing ring to form a coreless armature coil. At that time, said coreless frame-like coil is shaped into two or more kinds of coils of bracket shapes with slightly different heights, the two or more kinds of coils are placed shifting the phase with respect to each other such that one vertical side of one coil is positioned respectively in the gap of another coil, and they are sequentially affixed to the coil fixing ring, whereby there is obtained a coreless armature coil in which each phase of coil is placed uniformly and tightly on the same perimeter face.

Also, the brushless coreless motor of the present invention comprises a coreless armature coil obtained as noted above, and a ring-shaped rotating element with a multipole permanent magnet placed opposite the vertical side of the coreless armature coil, and constituted so as to have a penetration space in the center.

Said rotating element is supported so as to rotate freely by way of a bearing on the inner perimeter or outer perimeter of the ring-shaped frame of said fixing element, an encoder for rotation position control of the rotating element is provided between said ring-shaped frame and said rotating element, and a controlled member (driven member) can be established to penetrate the penetration space in the middle.

Also, said coreless rectangular frame-shaped coil can be either a wirewound or a sheet coil.

(Operation)

Because operating force is not generated in the upper side and lower side of the frame-like coil because the magnetic flux is parallel, the height-wise direction of the armature coil can be made lower without decreasing the operating force by shaping the coil into a bracket shape and affixing the upper side and lower side up-and-down in the gap part to the fixing ring. Also, because the coil is placed only on the side of the rotating element, it can be made thinner. Because each phase of coil of the armature coil does not cause a difference in distance with respect to the permanent magnet of the rotating element, coils where the operating force of each coil is equal can be obtained, the torque ripple is small, and the control is simplified.

Also, because each unit coil of the armature coil can be shaped independently of each other, and because they are a simple bracket shape, they can be easily shaped automatically. Moreover, because affixing to the fixing ring is simple, the manufacture of the armature coil is simplified and automation is easy, and the process can be greatly shortened compared with manufacturing armature coils of the past with coil wire wound in complex fashion to a core. Also, because automation is possible, there is no deviation of coil shape, and armature coils of uniform shape can be obtained.

Because the center of the motor is a penetration space, a controlled member can be established penetrating that penetration space. Accordingly, the range of uses can be expanded, such as can be used as

shown in Figure 3, compared with motors of the past where the controlled members can be connected only to the end of the output shaft, directly or by way of a relay member.

(Working Examples)

Below, working examples of the present invention are explained in detail based on drawings.

Figure 1 shows the procedures for shaping and assembling a coreless armature coil of a brushless coreless two-phase motor pertaining to the present invention.

First, as shown in (a) of the same figure, flat rectangular coil 1, having a rectangular gap part 2 in the middle where the height H is slightly greater than the height h of a fixing ring to be described later (about two times the coil thickness t) and the width W is about equal to the width w of the wound wire (width of the vertical side), /4 is obtained by winding wire, adhering, and shaping by well-known means. Next, that coil 1 is curved so as to follow the inner perimeter of fixing ring 4 made of a magnetic body (b). Next, that coil is shaped into a bracket shape by bending the upper and lower sides in the same direction such that the inner height h_1 of the bend becomes substantially equal to the height h of the fixing ring, whereby A-phase coil 3a is obtained (same figure (c)), and [the sides] are shaped into a bracket shape such that the inner height of the bend becomes $h_2 = h + 2t = H$, whereby B-phase coil 3b is obtained. A-phase coil 3a obtained in this manner is affixed to the inner perimeter of fixing ring 4 in a manner such that the upper and lower edges of the fixing ring are embraced by the bent upper and lower sides of the coil, and next B-phase coil is

affixed by shifting the phase such that the vertical side on one side is inserted into the gap part 2 of the A-phase coil. Doing similarly, with combinations of A-phase coils and B-phase coils, they are sequentially affixed to the fixing ring. By such means, a ring-shaped coreless armature coil with the vertical sides of A-phase coils and B-phase coils placed inside the same perimeter is obtained. Because the A-phase coils and B-phase coils of that armature coil do not cause a difference in distance with respect to the permanent magnet of the rotating element, coreless armature coil 5 having equal operating force of A-phase and B-phase coils is obtained.

The brushless coreless motor of the present working example having used an armature coil obtained in this manner is shown in Figure 2.

In the drawing, 6 is a base plate, and 7 is a cylindrical frame. Fixing ring 4 of coreless armature coil 5 obtained in said working example is affixed to the inner perimeter of that cylindrical frame by a suitable means such as screw 8. 10 is a hollow cylindrical rotating element, and multipole permanent magnet 11 is placed on the outer perimeter facing the vertical side of said coreless armature coil. 12 is a shaft coupler for supporting the cylindrical rotor to rotate freely on the cylindrical frame. 13 is an output shaft plate fixed to the top of that cylindrical rotor, and it relays the rotation of the rotating element to a driven body (or controlled body). In the present working example, it is a ring-shaped disk, but any suitable object can be used according to the shape of the driven body.

14 is a Hall element that detects the rotational position of the rotor, passes electricity to a specified armature, and performs

switching of phase, and it is affixed to the inner perimeter of the fixing ring. 15 is an encoder that detects the rotational position to perform rotational position control, and it consists of pulse disk 16 affixed to rotating element 10 and detection element 17 affixed to the base plate.

Figure 3 shows one use example of a brushless coreless motor constituted in the above manner.

This use example constitutes an ultra-precision positioning apparatus having combined three of the abovementioned coreless brushless motors. The base plate of second-stage motor 22 is fixed eccentrically on output plate 21 fixed to the upper end of the rotating element of first-stage motor 20, and in the same manner, third-stage motor 24 is fixed in a decentered position on output plate 23 of second-stage motor 22. When only first-stage motor 20 is driven in the position constituted in this manner, the second-stage and third-stage motors as a total motor rotate eccentrically around the first-stage motor with the amount of eccentricity respective of the first-stage motor as the radius of rotation. Similarly, when only the second-stage motor is rotated, the third-stage motor rotates with the amount of eccentricity respective of the second-stage motor as the radius of rotation. Accordingly, when the second-stage motor is affixed to a position decentered by distance L_1 with respect to the first-stage motor, and similarly when the third-stage motor is affixed being decentered by distance L_2 with respect to the second-stage motor, by rotating the first-stage motor and the second-stage motor independently, the eccentricity of the third-stage motor can be moved freely within a circle with $L_1 + L_2$ as the radius.

Accordingly, if the third-stage motor is affixed to a positioned body on the output plate and the first-stage and second-stage motors are driven, the positioned body can be translated within a two-dimensional surface just by the combination of their rotations, and ultra-precise positioning within the plane can be taken. Also, because positioning of the rotational direction of the positioned body is possible by rotating the third stage, an ultra-precision positioning apparatus can be obtained on three axes (X-Y-θ) of the positioned body by the combination of the rotations of the three motors.

Figure 4 is another working example of a brushless coreless motor /5
of the present invention, and it is a working example of an externally installed rotor-type.

In the working example, coreless armature coil 33 is constituted by affixing A-phase coil 31 and B-phase coil 32 obtained by processing as shown in Figure 1 (however, in the present working example, the direction of curving is opposite that in the case of Figure 1) to the outer perimeter of coil fixing ring 30, and a fixing element is formed by fixing that coil to the outer perimeter of cylindrical body 35 fixed to base plate 34. Also, rotating element 36 is constituted by affixing multipole permanent magnet 39 to said coreless armature coil 33 on the inner perimeter of cylindrical yoke 38 affixed to rotate freely by way of bearing 37 on top of said cylindrical body 35. In the drawing, 40 is a pulse disk, 41 is a pulse detector, and the two constitute an encoder. Also, 42 is a Hall element. The operating effect of the motor of the above constitution is identical to the aforementioned motor shown in Figure 2, except for the point that the rotor is externally installed.

Figure 5 is another working example of an armature coil. In the present working example, flat parallel four-sided modified-form coil 44 formed such that the vertical side of the coil slopes at an angle γ from the perpendicular to the bottom side is shaped in the same manner as the aforementioned working example to obtain A-phase coil 45a and B-phase coil 45b. Also, a vertical piece is affixed in a sloping manner to fixing ring 46 as illustrated. In this manner, by providing a slope to the coreless armature coil and combining it with the permanent magnet of the rotating element provided vertically, ripples can be made smaller.

The manufacturing method of the coreless armature coil of the present invention and one working example of a brushless coreless motor were shown, but the present invention is not limited to the case of two-phase type as in the above working example, it can be applied also to those of three-phase type and above, furthermore it goes without saying that many kinds of design modifications are possible within the range of the technical thinking thereof.

(Effects)

The present invention is constituted as above, and it offers exceptional effects such as the following compared with the prior art.

(1) Each unit coil of the armature coil can be constituted independently of each other, and because they are a simple bracket shape, they can be shaped easily. Moreover, because affixing to the fixing ring is simple, automation of the manufacture of the armature coil is easy to simplify, and the process can be greatly shortened compared with manufacturing methods of the past. Also, because automatic winding, shaping, and affixing by machine is possible, armature coils of

uniform shape can be obtained.

(2) Because the coil is shaped in a bracket shape and the upper side and lower side of the coil which do not generate operating force are affixed to a fixing ring, the height-wise direction of the armature coil can be made lower without decreasing the operating force. Also, because the coil is placed only on the side of the rotating element, it can be made thinner.

(3) Because each phase of coil of the armature coil does not cause a difference in distance with respect to the permanent magnet of the rotating element, coils where the operating force of each coil is equal can be obtained, and the torque ripple is small. Moreover, because there is no deviation in shape of the coils, the air gap with the rotor can be made smaller, a higher torque can be achieved compared with the brushless motors of the past, and the control is also simple.

(4) Because the rotating element is ring-shaped and the center part serves as a penetration space, a controlled member can be established penetrating that penetration space. Accordingly, the range of uses can be expanded compared with motors of the past where the controlled members can be connected only to the end of the output shaft, directly or by way of a relay member.

4. Brief Explanation of the Figures

The figures show working examples of the present invention. Figure 1 is a diagram of the manufacturing process of a coreless armature coil, Figure 2 is a frontal sectional view of a brushless coreless motor, Figure 3 is a side view of a triaxial ultra-precision positioning

apparatus being one example thereof, Figure 4 is a frontal sectional view of another working example of a brushless coreless motor, and Figure 5 is a diagram of the manufacturing process of another working example of a coreless armature coil.

1: flat rectangular coil, 2: gap part, 3a: A-phase coil, 3b: B-phase coil, 4,30,46: fixing ring, 5,33: coreless armature coil, 6,34: base plate, 7: cylindrical frame, 10,36: rotating element, 11,39: per- /6
manent magnet, 12,37: bearing [sic; 12 is the shaft coupler], 14,42: Hall element, 15: encoder, 20,22,24: brushless coreless motor

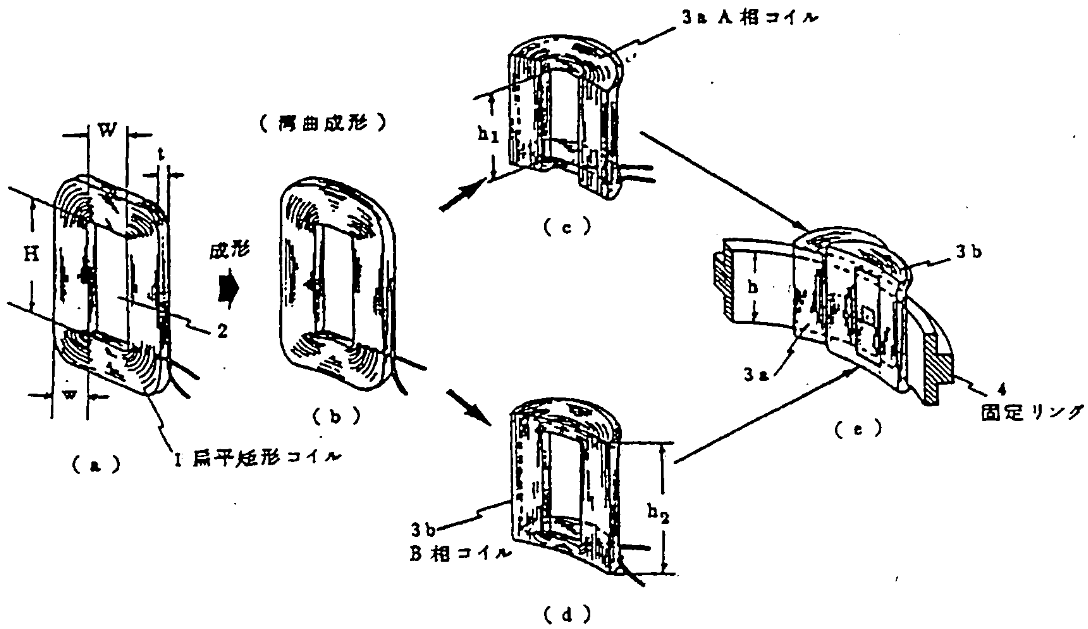

Figure 1

(a)
1: flat rectangular coil
[above 2:] shaping

(b)
(curve shaping)

(c)
3a: A-phase coil

(d)
3b: B-phase coil

(e)
4: fixing ring

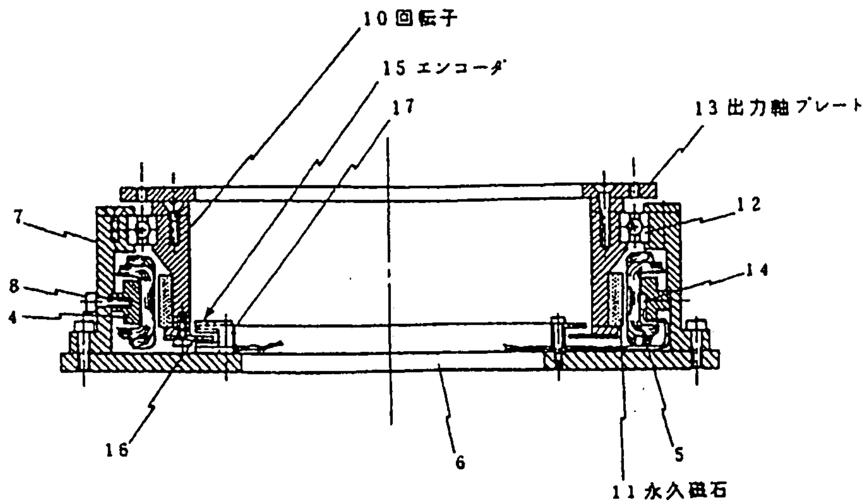

Figure 2
10: rotating element
11: permanent magnet
13: output shaft plate
15: encoder

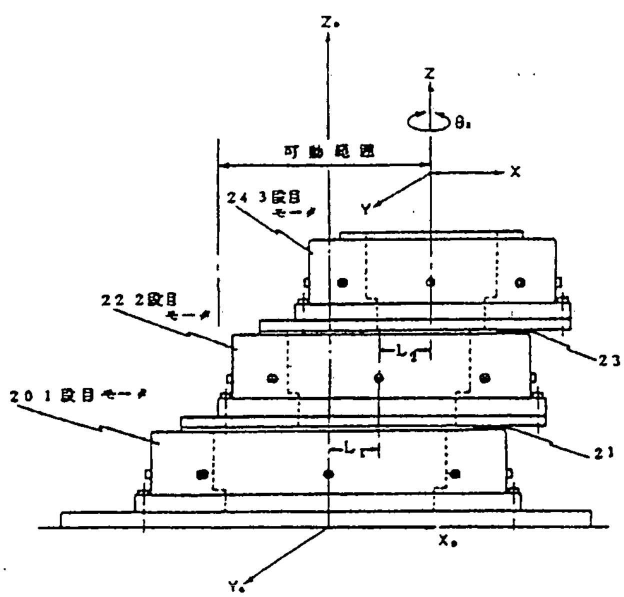

Figure 3
20: first stage motor
22: second stage motor
24: third stage motor
[above 24:] movable range

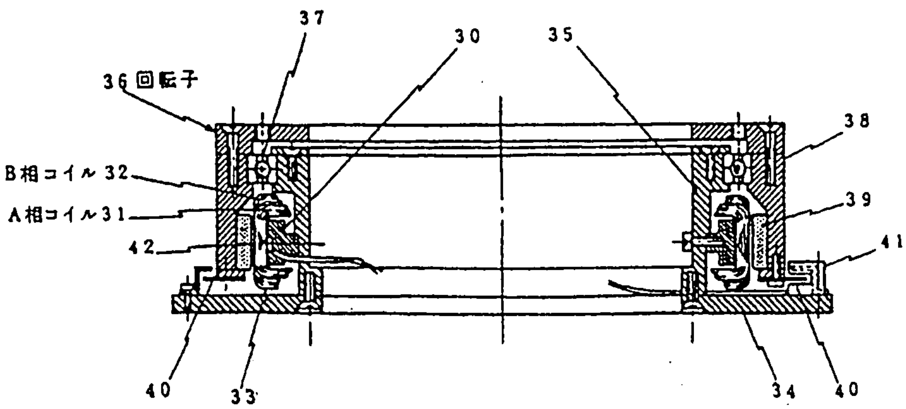

Figure 4
31: A-phase coil
32: B-phase coil
36: rotating element

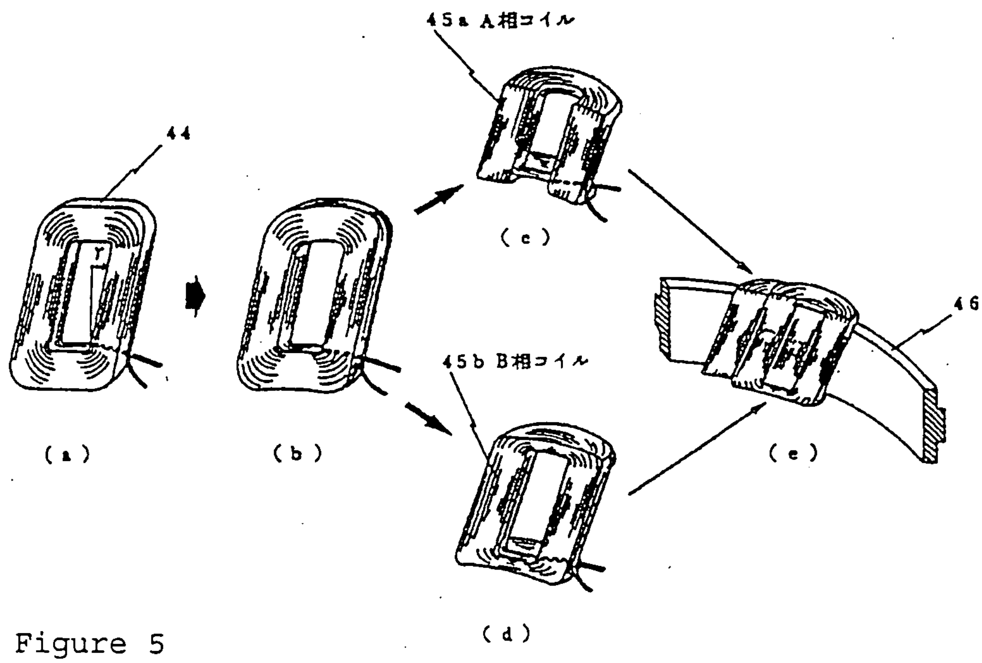

Figure 5

(c)
45a A-phase coil

(d)
45b B-phase coil